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Exterior noise, grip and rolling resistance levels of C1, C2 and C3 tyres in relation to the tyre noise directive (EU directive 2001/43/EC) and consumer interests.

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ABSTRACT

This paper presents exterior noise measurement on 194 tyres, which have been conducted recently in the framework of the Dutch Innovation Program for Noise. These data have been analyzed in relation to the recent evaluation of EU directive 2001/43/EC(ref [1]). On part of these tyres, besides exterior noise, also interior noise, wet grip and rolling resistance has been measured.

The noise emission of the tyres show a nearly perfect normal distribution with an average value about 3,5 dB below the limit in 2001/43/EC. Exterior noise appears to be highly correlated to interior noise in some frequency bands. A significant relation between noise level and technical specifications of the tyres (such as dimensions and speed index) is not found. The correlation between the noise properties of the tested tyres and other parameters such as wet grip, rolling resistance and market price is found to be negligible. The data presented here corroborate the conclusions in the FEHRL report (ref [2]).

1 INTRODUCTION

According to a recent Dutch study, noise is the second most important environmental factor, after the long term effect of particles, influencing the health of citizens in terms of Disability Adjusted Life Years (DALY's) (ref [5]). It is well known that road traffic noise is the most important source of environmental noise. High pressure to reduce traffic noise in the whole of Europe is expected starting from July 2007 when noise maps and action plans are expected as a result of the Environmental noise directive (ref [3]). Above a speed of about 50 km/h, tyre/road noise dominates the traffic noise emission (ref [6], [7], [8]). In this paper we will address the possibilities to reduce rolling noise by wider usage of low noise tyres.

Besides some local initiatives like the Blue Angel in Germany and the Nordic Swan in Scandinavia, the main initiative to reduce the noise emission of tyres is organized on an international harmonized level. The European Union has installed the tyre noise directive 2001/43/EC(ref [1]), which is obligatory for all the 27 EU member states. The United Nations Economic Commission for Europe has a nearly identical regulation R117 which can be acceded voluntarily by contracting parties. Besides most European countries, this regulation has been signed by countries like New Zealand and South Africa.

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The directive 2001/43/ requests the commission to study to what extend a further tightening of limit values can be achieved and to evaluate potential adverse effects for safety and rolling resistance. FEHRL (Forum of European Highway Research Laboratories) has been assigned to carry out this study. The report has been published on the internet (ref [2]) and an internet consultation round on this evaluation is expected for the summer of 2007.

In the framework of the Dutch Innovation Program on Noise (IPG) several data sets have been made available recently to the European Commission in (ref.[3]). This paper will discuss the data, compare it with the data set underlying the FEHRL study and conclude on potential tightening of the limit values.

2 TYRE NOISE DATA

2.1 Overview of available data sets

The noise measurements have been performed by M+P and RDW in a series of 8 sessions. In one session, apart from exterior noise, also the wet grip and the rolling resistance were measured. In another project also interior noise was measured. Some of the data of M+P (indicated with M+P 2003/2004) were already included in the FEHRL report.

An overview of the Netherlands measurement sessions and number of tyres involved is given in Table 1 below. This paper will present the data from the 6 sessions not included in the FEHRL study.

The following standardized methods where used for the measurements:

- Rolling sound emission: Directive 2001/43/EC.
- Wet grip: ISO 23 671 (C1 tyres only)
- Rolling resistance ISO- 8767 & ISO- 9948 (for C1 and C2/C3 tyres respectively)

Table 1: Exterior tyre noise data, measured in 8 successive sessions in the Netherlands. available for the evaluation of 2001/43/EC

nr	Measurement session/year	tyre class			Total number of tyres	wet grip	rolling resistance	Interior noise	Included in FEHRL report
		C1	C2	C3					
1	M+P 2002	23			23				
2	M+P 2003			24	24				X
3	M+P for Sintef 2004	20			20				X
4	M+P 2004	7			7				
5	M+P 2005			10	10				
6	RDW 2005	26	11	8	45	26 C1	26 C1, 19 C2/3		
7	RDW 2006	68			68			68 C1	
8	RDW 2006	40	1		41				
	Total number of tyres	184	12	42	238				

2.2 Noise data and comparison to the findings of others

The results of the data collection programs are presented in Figure 2 and Figure 3 below together with the relevant limit value in the present directive on tyre noise. The presented sound levels are obtained by subtracting 1 dB from the measured value and rounding down to the integer and thus can be compared directly against the limit value.

The C1 data show a statistical nearly perfect normal distribution with a standard deviation of 1,6 and an average value 3,6 dB below the limit value. This is 0,5 dB lower than the data from FEHRL (ref [5]), but equal to the data from ETRTO (ref[11]). The last data set is composed different from the FEHRL and NL set, since ETRTO presents type approval values, which according to the family principle, represents the worst case of a tyre family. Both the NL and the FEHRL data present tyres randomly selected from the population.

When there is such little difference between the worst case of a family and individual members of the family, we have to conclude that there is little spread in noise values within the family.

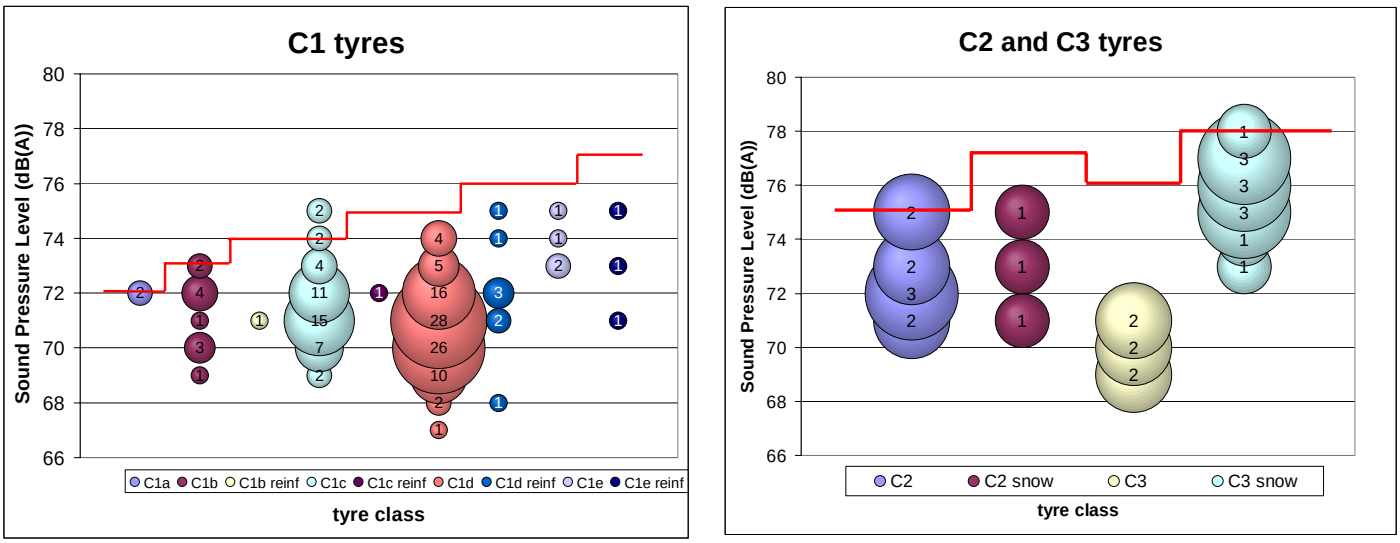

Figure 1: Results of the noise measurements. The sound levels present the values obtained after subtracting 1 dB from the measured value and rounding down to the integer. Left: data for passenger car tyres (C1), sorted as a function of their width and load class. The size of the circles and the numbers within it reflect the number of tyres been measured with this value. Right: truck tyres (C2 and C3). The C2 and C3 subclasses refer to the tyre designation according to 2001/43/EC. The red line represents the limit value in the present directive.

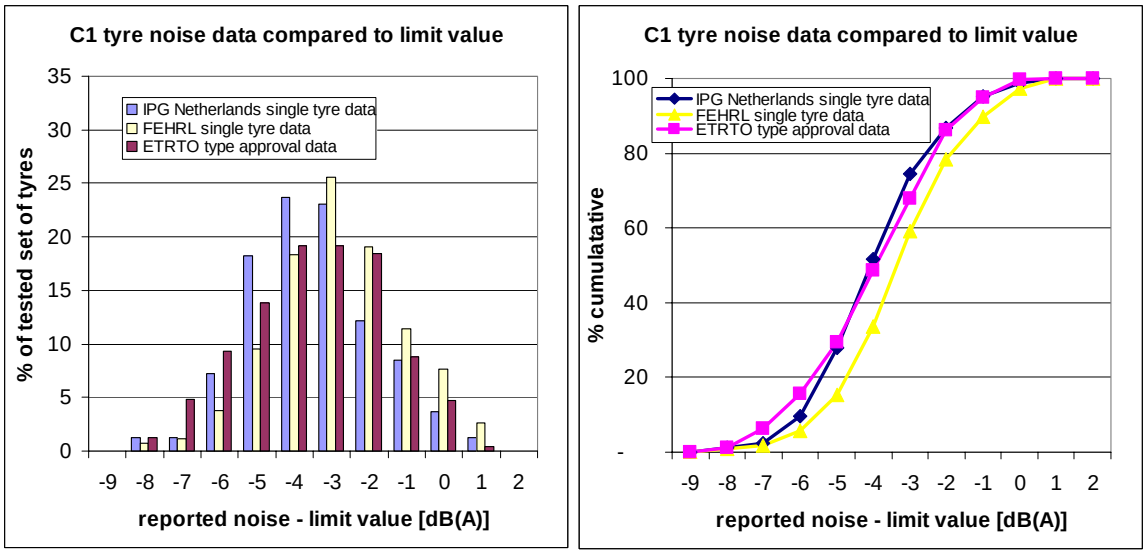

Figure 2: Distribution of tyre noise data from three different sources: 1) The IPG Netherlands with measurements on 165 single tyre sets as bought from the tyre shop 2) FEHRL with measurements on 262 single tyre sets as bought from the tyre shop 3) ETRTO with type approval data representing 536 tyre families

3 CORRELATION OF EXTERIOR NOISE LEVELS AND OTHER TYRE PARAMETERS

In this chapter an analysis is presented, in which the correlation between measured exterior noise levels of tyres were calculated with a wide variety of other parameters of the tyre.

3.1 Technical descriptors of the tyre (C1 only)

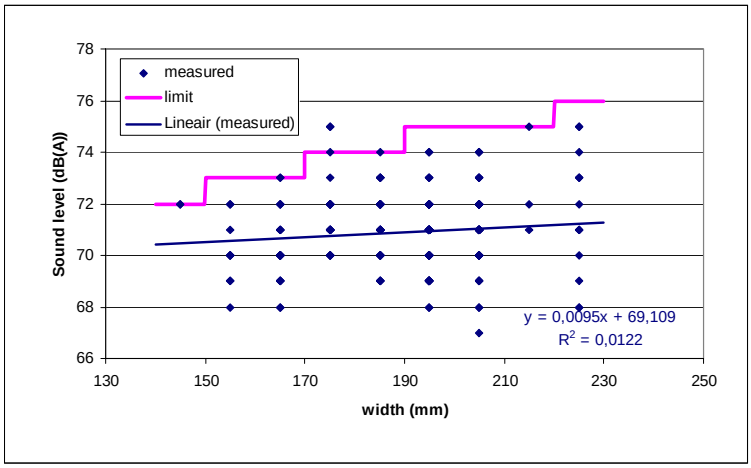

Figure 3: Noise values of C1 tyres in relation to the tyre width. The pink line represents the limit curve . Noise values include 1 dB subtraction and rounding down procedures.

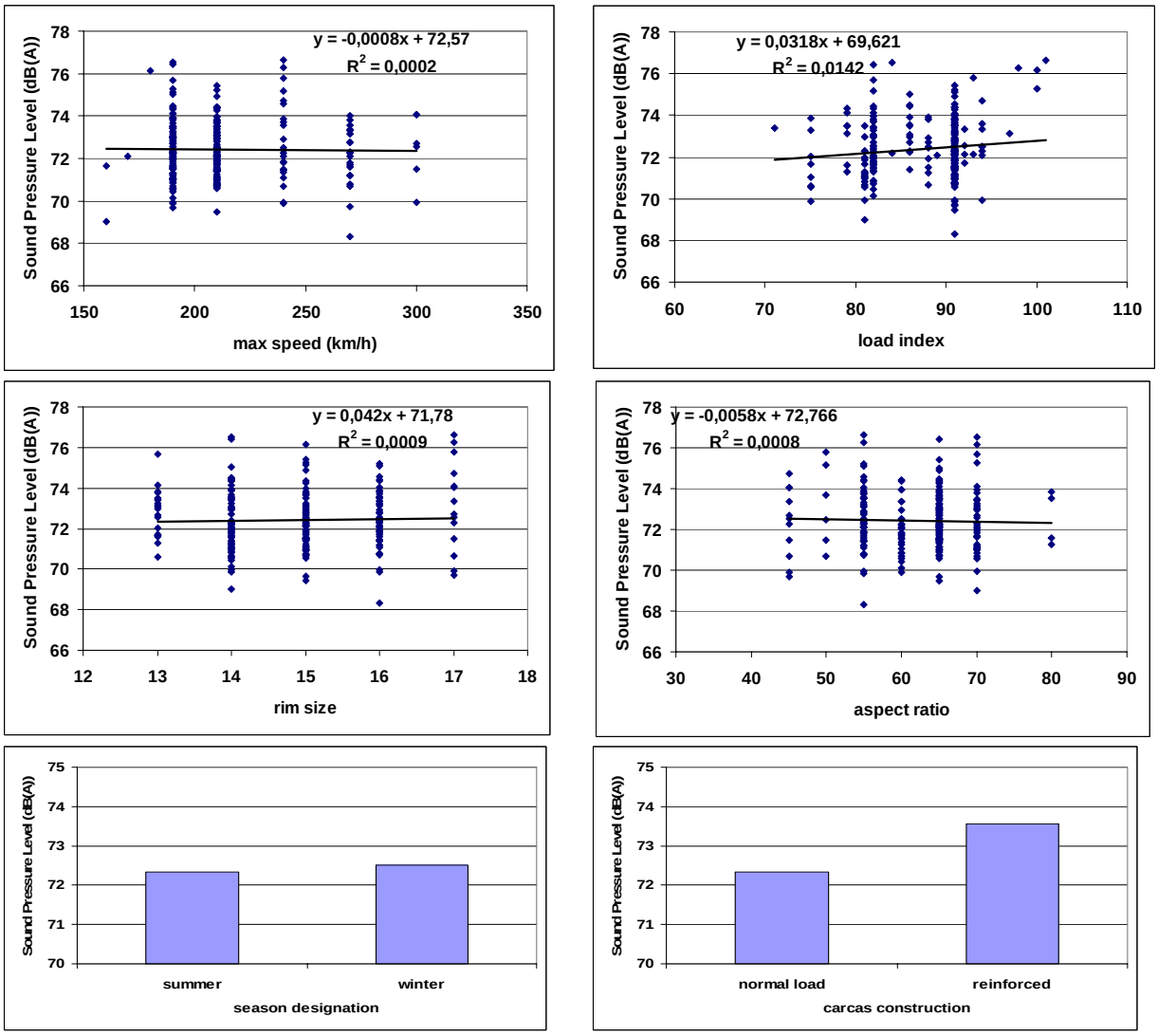

Figure 4: Measured sound levels (no subtraction or rounding applied) of C1 tyres in relation to the following six tyre parameters: a)maximum design speed, b) load index, c) rim size, d) aspect ratio, e) season designation and f) carcass construction, (All Netherlands data included)

Currently the limit system for C1 tyres depends on the width of the tyre (about 1 dB(A) per 20 mm for tyres below 215 mm). Also the limit is 1 dB higher for reinforced tyres. Figure 3 shows that the noise emission of the tested tyres hardly depends on the tyre width: the slope is lower (1 dB(A) per 100 mm) and the correlation is weak. In Figure 4 it can also bee seen that no significant correlation can be found between the exterior noise and any of the following parameters: a)maximum design speed, b) load index, c) rim size, d) aspect ratio, e) season designation. Figure 4f shows that the higher limit for reinforced tyres is confirmed by experimental evidence.

3.2 Wet grip and rolling resistance

A very important issue, to be investigated in relation with lowering of limit values are the safety and sustainability properties of tyres. Figure 5 and Figure 6 show the results of wet grip and rolling resistance. The graphs clearly demonstrate the lack of any correlation between wet grip and noise for the C1 tyres and between rolling resistance and noise for the population of C1 tyres, C2 tyres and C3 tyres. These findings corroborate the conclusion by FEHRL that selecting low noise tyres does not affect the safety nor the sustainability properties of the tyre population.

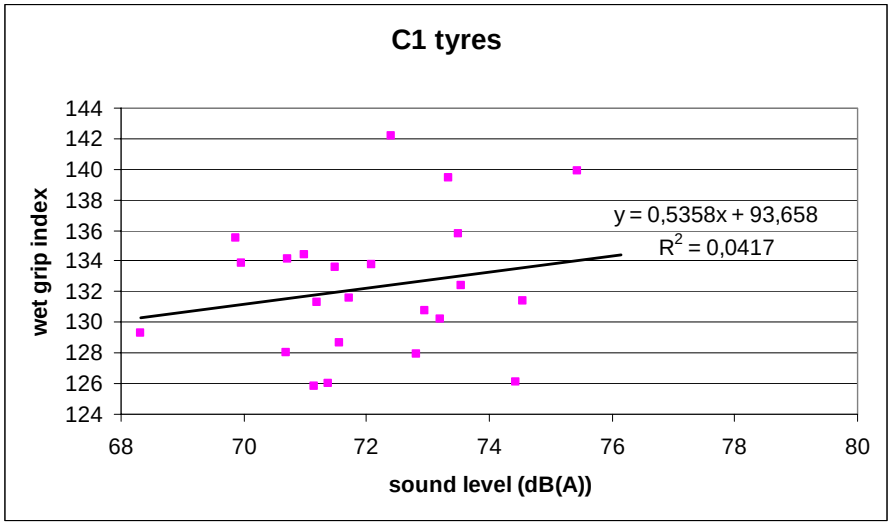

Figure 5: Scatter diagram of measured sound levels (no rounding or subtraction applied) against wet grip index of 26 C1 tyres

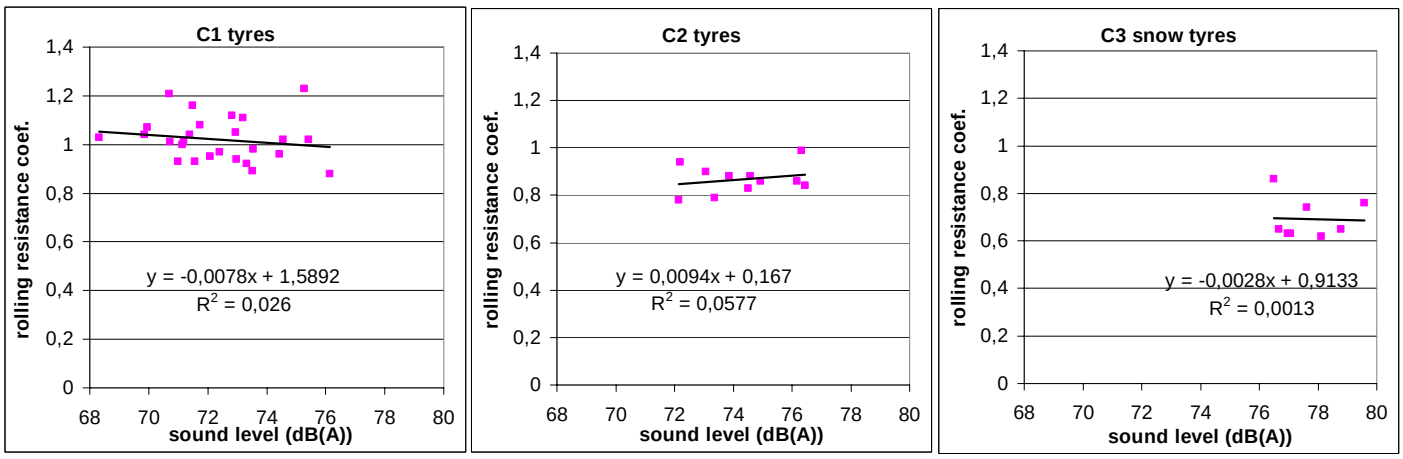

Figure 6: Scatter diagram and regression coefficients of exterior sound levels (no rounding or subtraction applied) against the rolling resistance of 26 C1 11 C2 standard tyres and 8 C3 snow tyres

3.3 Relation of exterior noise levels with consumer price and with interior noise levels

Wide introduction of low noise tyres has to take place by shifts in the buying process of consumers. Consumers will not be very interested in the exterior noise properties of tyres for but will be very interested in the price and possibly in the interior noise. Therefore we studied these relations. Figure 7 shows that there is a very weak correlation between exterior noise of a tyre and its price (only 5% of the variance explained by the consumer price). If all tyres are included, the highest prices occur at the highest noise levels, but this is because these tyres are also wider. Figure 7b shows that, within one size, the tendency is the other way around: the higher noise levels occur at the lowest price. But also this correlation is very weak (only 9% of the variance explained).

Figure 8 shows that, for the three investigated vehicles, there is a good correlation between interior noise and exterior noise of tyres in the frequency range around 1000 Hz . In both the low and high frequency range the low correlation can be explained by the significance of other sources, such as power train noise at low frequencies and aerodynamic noise at high frequencies.

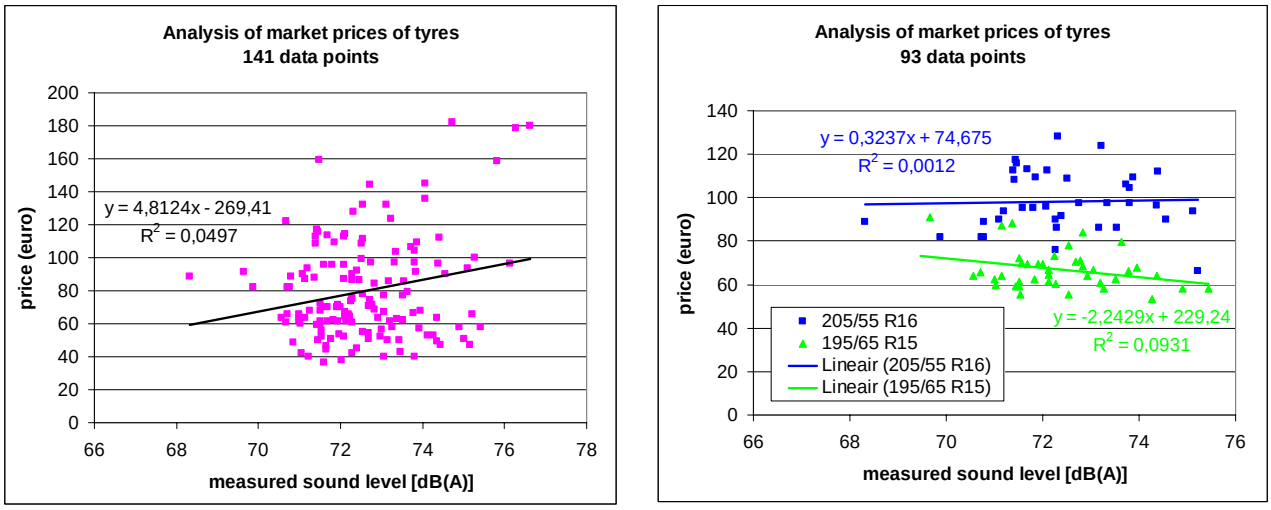

Figure 7: Scatter diagram of measured sound levels (no rounding or subtraction applied) against the market price. The left diagram shows all investigated tyres. The right diagram shows the two most popular tyre sizes.

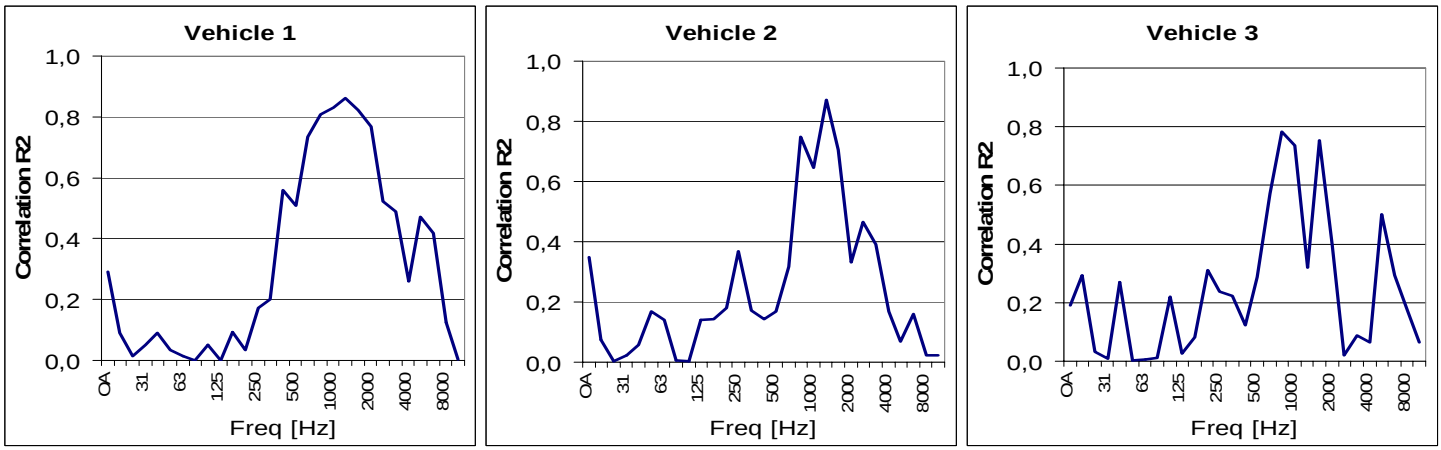

Figure 8: Correlation between the interior and exterior noise of 68 C1 tyres, as measured on 3 different vehicles.

4 DISCUSSION AND CONCLUSIONS

The work presented here shows measurement results on 238 tyres covering the C1, C2 and C3 categories. This data may contribute to the knowledge database that underlies the upcoming evaluation of the EU tyre noise directive 2001/43/EC.

The noise measurement results are on average 0,5 dB(A) more silent than the data in de FEHRL report and resembles the data presented by ETRTO. This means that the C1 tyres are on average 3,5 dB(A) below the limit. The most silent tyre is 8 dB(A) below the limit. For C2 and C3 tyres the amount of test results is smaller then that for C1 tyres, but still carries clear findings. For normal C3 tyres there is a significant margin of 5 to 7 dB between the limit value and the measurement results, while for normal C2 tyres there margin is smaller (0 to 4 dB).

A comparison between the corrections in the current limit system and the measurement results presented here lead to the following conclusions:

- The relation between tyre width and noise level of less than 1 dB per 100 mm found in our data set is much smaller the one currently incorporated in the C1 limit system.
- Reinforced tyres have on average a 1 dB higher noise level, which complies with the current limit system.
- The difference between C2 normal and C2 snow, as incorporated in the current limit system, could not be confirmed with the relatively small data set.
- The difference between C3 normal and C3 snow found here is much larger (about 6 dB) then the effect incorporated in the present limit system (2 dB).

A correlation between noise and wet grip or rolling resistance could not be found, nor could we detect a relation with the price of the tyre. A good correlation was found between interior and exterior noise of the tyres, especially in the mid frequency range around 1000 Hz.

We conclude that on base of the data presented here a shift in the rolling sound level of the tyre population in use, implemented through tightening of the limit value, will not affect the safety and sustainability properties of the tyre population. Since we could not detect any significant price difference between normal tyres and low noise tyres, we have to assume that tightening limit values will not carry external costs and that such a measure will have a cost/benefit ratio that is superior over other measures such as barriers or façade insulation.

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